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Life-cycle Carbon Emission Calculation and Reduction Strategies for Glass Curtain Wall Hotels

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Abstract

Based on the whole-life-cycle theory of building carbon emissions, this study takes a glass-curtain-wall hotel in Ganzhou City as an example, divides the hotel's life-cycle carbon emissions into five stages—material production, transportation, construction, operation and demolition—according to its material and mechanical consumption, and conducts corresponding carbon-reduction strategy research. The results show that the material production and operation stages contribute the most to the building's life-cycle carbon emissions. As the primary targets for carbon reduction, these stages can be addressed by extending the building's service life, improving the thermal performance of the envelope, and adopting low-carbon elevators, among other measures, to achieve emission reduction goals.

Keywords: Building carbon emissions; Whole life cycle; Carbon reduction; Hotel construction project; Carbon emission calculation

1 Introduction

In recent years, significant global climate change has drawn widespread international attention to greenhouse gas emissions and their control, making low-carbon development a new strategic goal across industries. In response, China proposed at the 75th UN General Assembly the key objectives of "striving to peak carbon emissions before 2030 and achieve carbon neutrality before 2060" . Research indicates that in 2021, China's total building lifecycle carbon emissions reached 4.07 billion tCO_2, accounting for 38.2% of energy-related carbon emissions . Therefore, achieving low-carbon development in the building sector is crucial for China's dual-carbon goals, with energy-intensive hotel buildings representing a key focus for energy conservation and emission reduction. Conducting research on lifecycle carbon emission calculation and reduction strategies for hotel buildings holds significant importance for advancing low-carbon development in the construction industry.

Carbon emission calculation and analysis serve as the foundation for studying whole-life-cycle carbon reduction in buildings, which not only helps accurately identify key emission phases and critical reduction factors at each stage, but also effectively guides low-carbon development throughout hotel construction phases including material production, transportation, construction, demolition, and operation. Since the Paris Climate Agreement, research on carbon emissions has intensified, with the construction sector as a key focus area, prompting numerous scholars to conduct micro-level studies on building carbon reduction. Domestically, Sun established three carbon-reduction calculation models (raw material utilization, enterprise production process, and material application) that conclusively demonstrate green building materials' contributions and potential for emission reduction. Zhang et al. conducted building carbon accounting through input-output analysis, revealing construction's significant driving effect on other sectors' emissions, and proposed that guiding material selection could reduce indirect emissions and achieve low-carbon material choices. Guo et al. developed a calculation formula for retrofit buildings' life-cycle emissions, providing theoretical support for low-carbon renovation projects. Li et al. simulated building energy-saving pathways under various policy scenarios using a Stars/Building comprehensive evaluation model, concluding that renewable energy utilization and heating system optimization significantly contribute to emission reduction.

Concurrently, international scholars have also conducted relevant research on building carbon emissions. Kou et al. proposed a novel passive solar house integrated with gravity heat pipes, achieving an envelope with variable thermal performance that efficiently utilizes solar energy for zero-carbon heating, thereby reducing building emissions. Jia et al. investigated SiO_2 aerogel-based low-carbon building materials utilizing CO_2 adsorption properties and carbonization technology, discovering that amino-modified aerogels significantly enhance carbon adsorption capacity, which can partially reduce emissions during building material production. Eum et al. implemented electricity-centric energy sharing systems (incorporating photovoltaics, battery storage, and energy management systems) in two Korean communities, enabling surplus energy trading and renewable energy utilization between communities and buildings, consequently reducing building emissions.

Current research on building decarbonization primarily focuses on conventional building typologies including office, cultural-educational, exhibition, and medical facilities, given their substantial societal prevalence and well-established energy/carbon emission patterns, making them representative models for building carbon emission studies. However, hotel buildings - as mixed-use commercial structures (integrating guest accommodations, entertainment, and food services) - remain under-investigated. This study addresses this gap by examining a glass curtain-walled hotel in Ganzhou City, conducting a comprehensive whole-life carbon assessment to identify critical emission drivers, develop tailored decarbonization strategies, and establish a methodological framework for future hotel carbon research.

2 Overview of Carbon Emission Calculation

2.1 Research Scope and Calculation Methodology for Carbon Emissions

The carbon emission calculation scope in this study encompasses the entire building life cycle, including emissions from five phases: material production, transportation, construction, demolition, and building operation, as well as carbon offsets from carbon sequestration and renewable energy during the operational phase. Building carbon emission calculation methods include the emission factor method, direct measurement method, and material balance method . This study employs the emission factor method, where energy and material consumption from each construction activity is multiplied by corresponding CO_2 emission factors to calculate carbon emissions at different life-cycle stages.

2.2 Sources of Carbon Emission Factors

The carbon emission factors used in the calculations were sourced from the "Standard for Building Carbon Emission Calculation" (GB/T 51366-2019) . For electricity consumption-related emissions, the average CO_2 emission factors of China's regional power grids were determined according to Table 1.

Table 1. Average CO_2 emission factors of regional power grids in China ($kgCO_2$ /kWh) .

Power Grid Name	Emission Factor
North China Regional Power Grid	0.8843
Northeast China Regional Power Grid	0.7769
East China Regional Power Grid	0.7035
Central China Regional Power Grid	0.5257
Northwest China Regional Power Grid	0.6671
Southern China Regional Power Grid	0.5271

2.3 Calculation Formula for Building Life-Cycle Carbon Emissions

The total carbon emissions over a building's entire life cycle comprise the sum of emissions from material production, transportation, construction, demolition, and operational phases, expressed mathematically as:

$$C = C_1 + C_2 + C_3 \tag{1}$$

Where: C — Total CO_2 emissions over building life cycle;

C_1 — Emissions from material production and transportation;

C_2 — Emissions from construction and demolition;

C_3 — Operational phase emissions.

(1) The calculation formula for carbon emissions during material production and transportation phases

$$C_1 = C_{sc} + C_{ys} \tag{2}$$

$$C_{sc} = \sum_{i=1}^{n} M_i F_i \tag{3}$$

$$C_{ys} = \sum_{i=1}^{n} M_i D_i T_i \tag{4}$$

Where: C_{sc} — Carbon emissions in material production phase;

C_{ys} — Carbon emissions in transportation phase;

M_i — Consumption quantity of the i-th primary building material;

F_i — Carbon emission factor of the i-th primary building material;

D_i— Average transport distance of the i-th primary building material;

T_i — Unit carbon intensity factor for transport of the i-th primary building material (per weight-distance).

(2) The calculation formula for carbon emissions during the construction and demolition phase is:

$$C_2 = C_{\mathrm{jz}} + C_{\mathrm{cc}} \tag{5}$$

$$C_{\mathrm{jz}} = \sum_{i=1}^{n} C_{bi} N_i \tag{6}$$

$$C_{\mathrm{cc}} = \left(C_{\mathrm{sc}} + C_{\mathrm{ys}} + C_{\mathrm{jz}}\right) \times k \tag{7}$$

Where: C_{jz} — Carbon emissions in construction phase;

C_{cc} — Carbon emissions in demolition phase;

C_{bi} — Carbon emission factor of the i-th construction machinery;

N_i — Working-shift quantity of the i-th construction machinery;

k — Percentage (typically 10%).

(3) The calculation formula for operational phase carbon emissions is:

$$C_3 = \left(C_{\mathrm{sy}} - C_{\mathrm{th}} - C_{\mathrm{zs}}\right) \times y \tag{8}$$

Where: C_{sy} — Operational carbon emissions, including emissions from building lighting, heating, air conditioning, domestic hot water, and other operational demands;

C_{th} — Carbon reduction from vegetation carbon sinks;

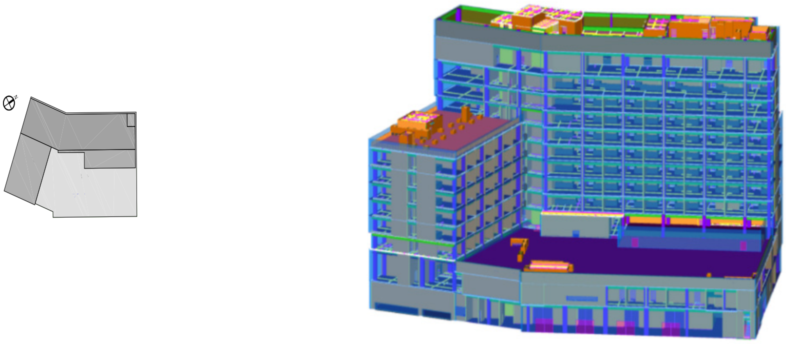
C_{zs} — Carbon reduction from renewable energy systems;

y — Building design service life.

3 Carbon Emission Calculation for Hotel Buildings

3.1 Project Overview

The newly constructed glass-curtain-wall hotel is located in Zhanggong District, Ganzhou City, Jiangxi Province—a hot summer and warm winter zone. This public hotel building comprises 12 above-ground floors (excluding basement), oriented 22.6° east of south (see Figure 1). The structure employs a frame-shear wall system with a 50-year design service life, featuring a floor area of 24,436.55 m², total volume of 119,122.02 m³, and height of 51.2 m.



(a) (b)

Figure 1. Hotel layout plan:(aplan view, and (b) three-dimensional view.

3.2 Life-Cycle Carbon Emission Calculation Results

The compiled calculations yield the hotel's total life-cycle carbon emissions as summarized in Table 2.

Based on Table 2, the compositional analysis of carbon emissions across the hotel's life-cycle phases is summarized as follows:

(1) Material Production Phase. Carbon emissions in this phase primarily originate from the manufacturing processes of building materials and components. The calculated materials must constitute ≥95% of the total construction material weight . The computed carbon emissions for material production amount to 14,525.16 tCO_2e.

(2) Material Transportation Phase. Carbon emissions in this phase include both direct emissions from material transport between production sites and construction locations, and indirect emissions from energy production for transportation . The CO_2 emissions primarily depend on transport modes, distances, and related factors. Given the absence of actual transport data, emissions were estimated at 4% (midpoint of 3%-5% range) of material production phase emissions, yielding 581.01 tCO_2e for this project.

(3) Construction Phase. Carbon emissions during this phase primarily originate from the operation of construction machinery and equipment on-site. The calculated emissions for the construction phase amount to approximately 798.77 tCO_2 e.

(4) Demolition Phase. As the final lifecycle stage, demolition emissions primarily derive from: demolition equipment operation, waste treatment processes, and material recycling activities. Being a new construction project, the demolition emissions were estimated at 10% of total construction phase emissions, yielding 1,590.49 tCO_2 e through calculated projections.

(5) Operational Phase. The emission calculation encompasses: lighting/electrical equipment, hot water & solar heaters, elevators, HVAC systems, ventilation, renewable energy, and building carbon sequestration over a 50-year operational lifespan. The total operational emissions across all categories amount to 54,762.35 tCO_2 e based on calculated data. Notably, the negative emission value for solar water heaters reflects their renewable energy benefits - achieving zero-carbon heat supply while significantly reducing reliance on fossil fuels and grid electricity, thereby creating net emission reductions.

Table 2. Building life-cycle carbon emissions summary table

Life Cycle Stage	Emission Source	Total Carbon Emissions(tCO_2 e)	Annual Carbon Emissions ($kgCO_2$ e/a)	Carbon Emission Intensity($kgCO_2$ e/($m^2 \cdot a$))	Emission Proportion(%)
Building Materials Production & Transportation	Subtotal	15106.17	302123.40	12.36	20.91
	Materials Production	14525.16	290503.20	11.89	20.10
	Materials Transportation	581.01	11620.20	0.48	0.80
Construction & Demolition	Subtotal	2389.26	47785.20	1.96	3.31
	Construction	798.77	15975.40	0.65	1.11
	Demolition	1590.49	31809.80	1.30	2.20
Building Operation	Subtotal	54762.35	1095247.00	44.82	75.79
	Hot Water	-2423.53	-48470.60	-1.98	-3.35
	Lighting	11092.31	221846.20	9.08	15.35
	HVAC	31761.54	635230.80	26.00	43.96
	Elevators	4559.34	91186.80	3.73	6.31
	Fresh Air System	86.05	1721.00	0.07	0.12
	Indoor Equipment	10415.09	208301.80	8.52	14.41
	Renewable Energy	-458.05	-9161.00	-0.37	-0.63
	Carbon Sink	-270.40	-5408.00	-0.22	-0.37

Total	72257.78	1445155.60	59.14	100.00	

3.3 Life-Cycle Carbon Emission Results Analysis

Through systematic analysis of Table 2 data, a 3D pie chart (Figure 2) was generated to visualize phase-wise emission contributions. The analysis reveals operational phase emissions dominate at 75.79% of the total. Material production follows at 20.10%, with minimal contributions from transportation (0.80%), construction (1.11%), and demolition (2.20%) phases.

As a hospitality-sector public building, this hotel's operational emission share (75.79%) aligns with documented life-cycle benchmarks for similar buildings (Table 3), validating the proportional distribution. Combined with the climatic characteristics of the project site, it can be found that the place is hot in summer and warm in winter, short in heating and severe cold, and has low dependence on HVAC, but due to the full-time operation of hotel buildings, the carbon emissions in the operation stage of this project are still higher than those of ordinary office, exhibition and cultural and educational buildings, and lower than those of medical buildings.

Table 3. Carbon emission distribution by building typology in public construction projects.

Reference	Location	Building Type	Operational Stage Carbon Emissions (%)	Material Production Stage Carbon Emissions (%)
Ref. [14]	Xiamen, Fujian Province	Office Building	79.38	17.69
Ref. [15]	Xiong'an New Area, Hebei Province	Cultural & Educational Building	71.55	24.02
Ref. [16]	Not Specified	Exhibition Building	74.61	20.33
Ref. [17]	Zhenjiang, Jiangsu Province	Office Building	74.24	24.79
Ref. [18]	Guangzhou, Guangdong Province	Cultural & Educational Building	68.00	30.03
Ref. [19]	Huai'an, Jiangsu Province	Medical Building	81.96	14.59
This project	Ganzhou, Jiangxi Province	Hotel Building	75.79	20.10s.

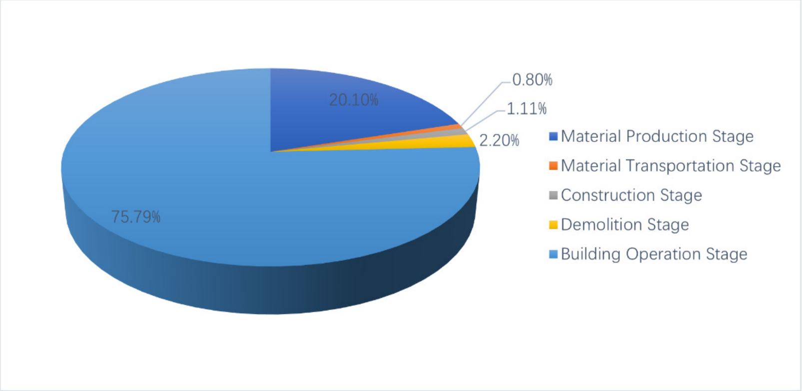


Figure 2. Carbon emission distribution across building life cycle phases.

Therefore, the hotel's emission distribution being validated, subsequent analysis will focus on:

(1) Life-Cycle Carbon Emission Analysis. Table 2 indicates the hotel's annual emissions reach 1,445,155.60

kgCO$_2$e/a, with total emissions of 72,257.78 tCO$_2$e. The operational phase dominates at 54,762.35 tCO$_2$e (75.79%), followed by material production at 14,525.16 tCO$_2$e (20.10%), while other phases collectively contribute only 2,970.27 tCO$_2$e (4.11%). Thus, emission reduction efforts must prioritize operational and material production phases - effective management of these two phases alone can achieve 95.89% of total reduction potential, making other phases secondary for this study's decarbonization focus.

(2) Material Production Phase Analysis. The calculations reveal that steel rebar, aluminum alloy profiles, concrete, and concrete blocks constitute the primary emission sources, with rebar and aluminum alone accounting for 46.51% of this phase's total emissions. Notably, these high-recyclability materials (rebar: 90-95%, aluminum: 75-80%) play pivotal roles in both emission reduction and sustainable material cycles. Adopting circular economy principles through increased utilization of recyclable materials—particularly high-recovery-rate green materials like rebar and aluminum—can accelerate decarbonization in material production.

(3) Operational Phase Analysis. Accounting for the largest lifecycle emission share (75.79%), operational emissions accumulate progressively through decades of energy consumption, contrasting with upfront carbon from other phases. Figure 3 analysis reveals HVAC systems as the dominant source (31,761.54 tCO$_2$ e total; 635,230.80 kgCO$_2$ e/a), constituting 58% of operational emissions, with lighting (20.3%), plug loads (19%), and elevators (8.3%) as significant secondary contributors. Thus, targeted decarbonization strategies should address all operational subsystems to establish replicable solutions for comparable projects.

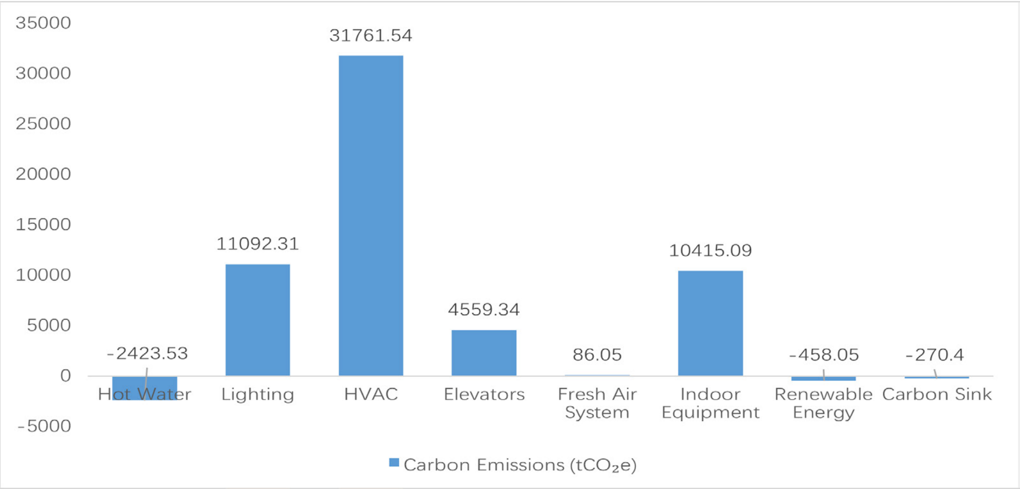


Figure 3. Composition of operational carbon emissions.

4 Decarbonization Strategies for Hotel Buildings

4.1 Analysis of Influencing Factors for Hotel Building Life-Cycle Carbon Emissions

Life-cycle emission analysis demonstrates that effective decarbonization requires prioritized interventions in both material production and operational phases. Luo's research [20] verified that substituting virgin steel with recycled alternatives achieves 79% emission reduction. Thus, increasing sustainable material utilization—particularly green building materials—presents a verified pathway for production-phase decarbonization. Given operational phases' dominant 75.79% contribution and multifactorial dependencies, this study focuses on five key determinants: design service life, envelope thermal transmittance, elevator energy class, HVAC heating modes, and local climate—to develop targeted mitigation strategies.

4.1.1 Impact of Building Design Service Life

Operational carbon emissions accumulate progressively throughout a building's service life, making the study of design service life crucial for understanding whole-life carbon impacts. As demonstrated in Table 4, increasing the design service life leads to cumulative growth in operational emissions while maintaining constant emissions in other life-cycle stages. Extending the design service life from 30 to 70 years reduces annualized life-cycle emissions by up to 333,247.14 $kgCO_2$ e/year (19.86% reduction). This suggests that lifespan extension constitutes an effective decarbonization strategy.

Table 4. Impact of design service life on building carbon emissions

Year	Materials Production & Transportation(tCO_2 e)	Construction & Demolition (tCO_2 e)	Building Operation(tCO_2 e)	Total Carbon Emissions (tCO_2 e)	Operational Emissions Proportion(%)
30	15106.17	2389.26	32857.44	50352.87	65.25
40			43809.96	61305.39	71.46
50			54762.35	72257.78	75.79
60			65714.86	83210.29	78.97
70			76667.30	94162.73	81.42

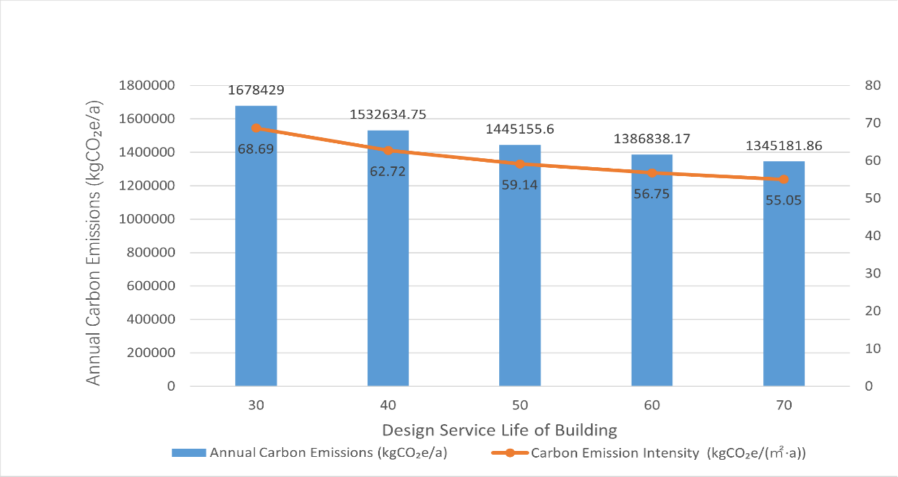


Figure 4. Impact of building design service life on carbon emissions.

4.1.2 Impact of Building Envelope Thermal Transmittance (U-value)

Research indicates that the thermal transmittance (U-value) of exterior walls has a more pronounced impact on operational carbon reduction compared to windows or roofing systems, establishing wall U-values as the critical parameter for emission control studies. The case-study hotel features a curtain wall system comprising: Thermally broken aluminum frames, Low-E insulated glazing (SuperSE-16mm+12A+6mm configuration), Overall U-value: 2.2 W/(m²·K). Table 5 presents alternative glazing assemblies, while Figure 5 demonstrates the inverse correlation between glazing U-values and life-cycle carbon savings (Δ = Baseline emissions - Optimized emissions). The analysis reveals a 62.3% U-value reduction (2.2→0.97 W/(m²·K)) yields carbon savings of 7,962.69 tCO_2e, equivalent to 14.5% of baseline operational emissions. Therefore, specifying high-performance glazing systems with lower U-values—while maintaining structural integrity—should be prioritized for achieving decarbonization targets.

Table 5. Thermal transmittance coefficients of various curtain wall glazing types

Category	Curtain Wall Glass Specification	Thermal Transmittance (U-value) ($W/(m^2\cdot K)$)
1	Low-E Insulated Glass (SuperSE-16mm + 12A + 6mm) (This Project)	2.20
2	Double Glazing (Low-E + Clear), 6mm Air-filled	2.16

3	Double Glazing (Low-E + Clear), 6mm Argon-filled	1.99
4	Double Glazing (Low-E + Clear), 12mm Air-filled	1.70
5	Double Glazing (Low-E + Clear), 12mm Argon-filled	1.53
6	Triple Glazing (Low-E + Clear), 12mm Air-filled	1.42
7	Triple Glazing (Low-E + Clear), 12mm Argon-filled	0.97

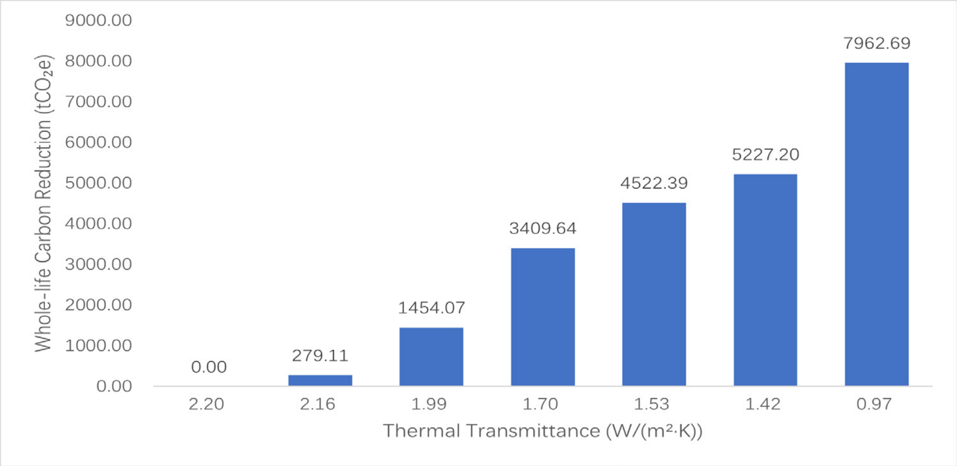


Figure 5. Impact of curtain wall glazing U-values on building carbon emissions.

An economic analysis of alternative glazing systems (Table 6) reveals Option 2 as the lowest-cost solution (¥2.0058 million) and Option 1 as the most expensive (¥4.346 million). All alternative glazing configurations demonstrate superior cost-carbon performance compared to the baseline selection, achieving both economic and emission reduction benefits. Option 7 delivers peak carbon savings (¥534,900 cost reduction), while Option 4 achieves optimal balance - reducing emissions by 3,409.64 tCO_2 e with ¥2.0727 million savings. Option 2, though lowest-cost, shows limited decarbonization efficacy. Thus, Option 4 (double glazing: Low-E + clear, 12mm air gap) emerges as the Pareto-optimal solution, simultaneously maximizing cost-efficiency and carbon reduction.

Table 6. Economic cost analysis of various curtain wall glazing systems

Option	Curtain Wall Glass Specification	Total Glass Area(m^2)	Unit Cost(CNY/m^2)	Total Cost($\times 10^4$ CNY)	Whole-Life Carbon Reduction(tCO_2 e)
1	Proposed Glass Solution (This Project)	13372.187	325	434.60	0
2	Double Glazing (Low-E + Clear), 6mm Air Gap		150	200.58	279.11
3	Double Glazing (Low-E + Clear), 6mm Argon-filled		175	234.01	1454.07

4	Double Glazing (Low-E + Clear), 12mm Air Gap		170	227.33	3409.64
5	Double Glazing (Low-E + Clear), 12mm Argon-filled		200	267.44	4522.39
6	Triple Glazing (Low-E + Clear), 12mm Air Gap		225	300.87	5227.2
7	Triple Glazing (Low-E + Clear), 12mm Argon-filled		285	381.11	7962.69

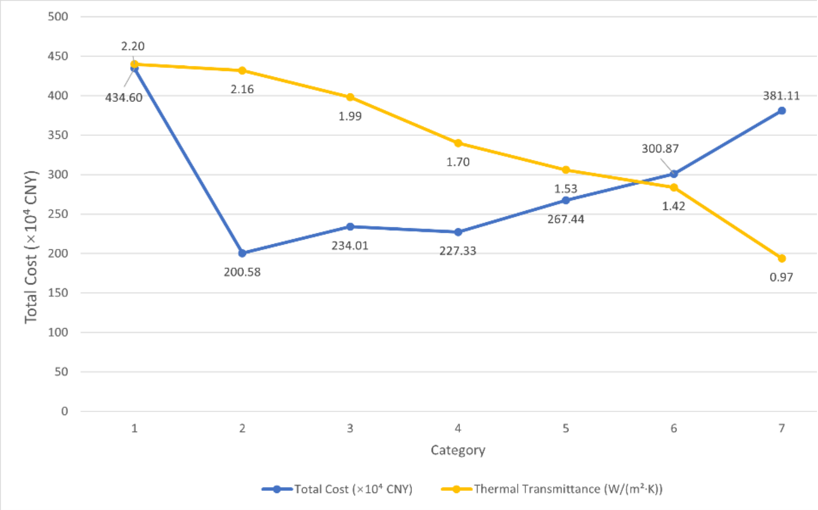


Figure 6. Relationship between curtain wall glazing costs and thermal transmittance (U-value)

4.1.3 Impact of Elevator Energy Performance Class

Figure 7 illustrates the correlation between elevator energy performance classes (Classes 1-6) and operational carbon emissions. The data demonstrates a positive correlation: higher energy classes (e.g., Class 6) increase both energy use and emissions, whereas lower classes (e.g., Class 1) enhance efficiency - with Class 1 achieving 85.88% emission reduction versus Class 6. This 85.88% reduction potential positions elevator optimization as a key leverage point for building decarbonization. Strategic selection of high-efficiency elevators (Class 1-2) can significantly reduce both operational energy use and lifecycle carbon footprint.

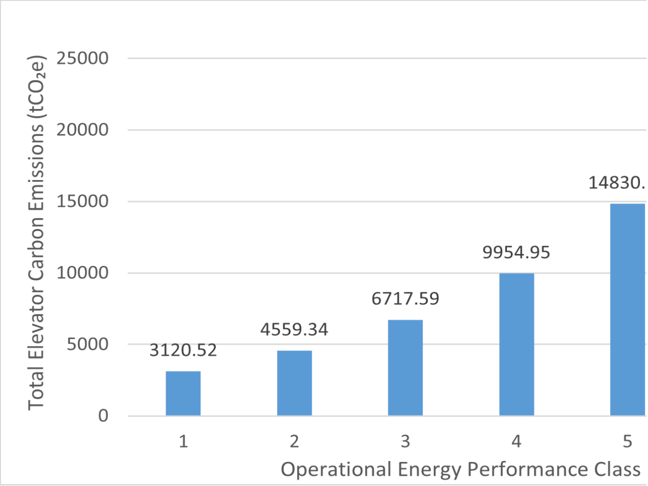


Figure 7. Carbon emissions from elevator operation at different energy performance levels.

4.1.4 Impact of HVAC Heating/Cooling System Configurations

As shown in Figure 3, HVAC systems account for 58% of operational phase emissions, establishing their configuration as the critical determinant for building decarbonization. This study evaluates three HVAC configurations for hotels: VRF/split systems, ground-source heat pumps (GSHP), and air-source heat pumps (ASHP), with their emission performance quantified in Table 7. The analysis reveals an emission hierarchy: VRF/split > ASHP > GSHP, positioning GSHP as the optimal technical choice when disregarding capital costs and site constraints. Figure 8 demonstrates that higher COP (heating) and EER (cooling) values directly correlate with energy efficiency, recommending specification of high-performance equipment for emission reduction.

Table 7. Study on heating and cooling modalities of diverse HVAC systems

System Type	Heating Performance(COP)	Cooling Efficiency(EER)	Total Carbon Emissions(tCO_2 e)	Annual Carbon Emissions($kgCO_2$ e/a)
VRF Systems & Split Units	2.3	2.3	31761.54	635230.80
Ground Source Heat Pumps	5.5	5	14595.70	291914.00
Air Source Heat Pumps	2.6	3	24391.75	487835.00

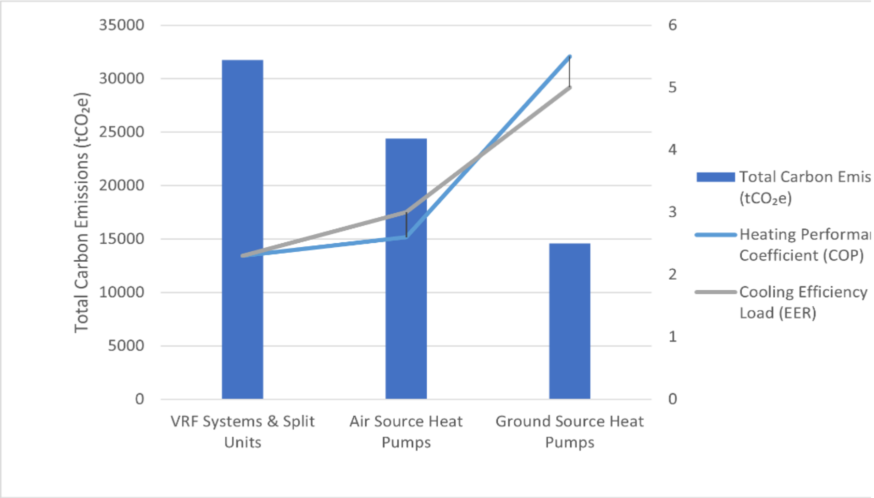


Figure 8. The impact of different heating and cooling modes in HVAC systems on building carbon emissions

4.1.5 Impact of Local Climate Conditions

Building location climate significantly impacts carbon emissions, per China's "Building Climate Zoning Standard" GB 50178-1993 which classifies seven primary zones: Severe Cold, Cold, Hot Summer-Cold Winter, Hot Summer-Warm Winter, Temperate, Plateau, and Special Climate Regions. Emission calculations were conducted for representative cities in each zone while holding other parameters constant, revealing that climate primarily affects operational-phase emissions. Extended heating/cooling demands in Severe Cold, Cold, and Special Climate Regions increase HVAC reliance, consequently elevating operational emissions (Table 8). Thus, climate-appropriate building systems can mitigate location-dependent emissions. For electricity-related emissions, regional grid CO_2 emission factors (Table 1) must be applied per building location.

Table 8. Research on climatic conditions at various building locations

Climate Zone Type	City	Building Materials Production & Transportation(tCO_2e)	Construction & Demolition(tCO_2e)	Building Operation(tCO_2e)	Total Carbon Emissions(tCO_2e)	Annual Carbon Emissions($kgCO_2e/a$)
Severe Cold Region	Hohhot	15106.17	2389.26	74967.80	92463.23	1849264.60
Cold Region	Beijing			67007.63	84503.06	1690061.20
Hot Summer & Cold Winter Region	Nanjing			51845.29	69340.72	1386814.40
Hot Summer & Warm Winter Region	Ganzhou			54762.35	72257.78	1445155.60
Temperate Region	Kunming			33034.67	50530.10	1010602.00
Plateau Climate Region	Lhasa			40217.51	57712.94	1154258.80
Special Climate Region	Dunhuang			65953.90	83449.33	1668986.60

4.2 Decarbonization Strategies for Hotel Buildings

Based on operational emission factor analysis, the following decarbonization strategies are proposed for hotel buildings:

(1) Extend the design service life of buildings. Research analysis shows that extending hotel building design life from 50 to 70 years reduces annual life-cycle carbon emissions by 99,973.74 kgCO2e/a (6.92% decrease), with carbon intensity dropping by 4.09 kgCO2e/(m^2·a). Therefore, prior to construction, structural design should be systematically optimized to enhance durability and material longevity. During construction, strict adherence to building codes is essential to minimize lifespan reduction from poor workmanship. Post-construction, regular preventive maintenance and monitoring should be implemented to mitigate damage from external factors. After prolonged use, functional retrofits complying with national regulations can further extend building lifespan, conserving resources and reducing carbon emissions.

(2) Prioritize exterior wall enclosures with low heat transfer coefficients. Analysis of the heat transfer coefficient factor shows that replacing the hotel curtain wall glass from Low-E insulated SuperSE-16mm+12A+6mm to triple-pane (Low-E+clear) 12mm argon-filled glass reduced building emissions by 7,962.69 tCO2e. The heat transfer coefficient relates to the insulation performance of enclosure materials - better insulation leads to lower coefficients. Therefore, while ensuring structural safety, curtain wall glass with superior insulation should be prioritized to minimize energy waste from heat transfer.

(3) Adopt low-carbon and energy-efficient elevators. After upgrading the elevator energy performance level from Grade 2 to Grade 1 in the hotel building, carbon emissions were reduced by 1,438.82 tCO_2e. Improving elevator energy efficiency at the design stage can reduce reliance on electricity and consequently lower building carbon emissions.

(4) Select a heating and air-conditioning system with higher COP (Coefficient of Performance) for heating and EER (Energy Efficiency Ratio) for cooling under full load. Higher COP and EER values indicate that the system provides more heating or cooling output for the same energy consumption, thereby reducing carbon emissions from energy use. Based on the earlier analysis of factors influencing heating and cooling performance, switching hotel buildings from multi-split and split air-conditioning systems to ground-source heat pumps could reduce carbon emissions by approximately 17,165.84 tCO_2e. Therefore, prioritizing heating and cooling systems with high COP and EER values contributes to building decarbonization.

(5) Adapt to local conditions and select appropriate construction and emission-reduction solutions. Since the local climate is an unchangeable geographical factor, construction techniques and building equipment should be chosen based on regional climate conditions, resource availability, and cultural characteristics to minimize unnecessary carbon emissions caused by geographical constraints.

5 Conclusion

Through computational analysis of the whole life-cycle carbon emissions of glass curtain wall hotels in Ganzhou City, this study draws the following conclusions:

(1) The building material production and operational phases are critical stages for carbon emissions, accounting for 20.10% and 75.79% of the total building carbon emissions, respectively. Based on a 50-year design service life, the building's annual carbon emissions reached 1,445,155.60 kgCO_2 e/a, with total emissions amounting to 72,257.78 tCO_2 e.

(2) Life-cycle carbon emission analysis revealed that extending the building design lifespan from 50 to 70 years reduces annual carbon emissions by 99,973.74 kgCO_2 e/a (6.92% reduction), with carbon intensity decreasing by 4.09 kgCO_2 e/(m^2·a). Replacing curtain wall glass from Low-E insulated SuperSE-16mm+12A+6mm to triple-pane (Low-E+clear) 12mm argon-filled glass reduced hotel emissions by 7,962.69 tCO_2 e. Upgrading elevator energy performance from Grade 2 to Grade 1 decreased carbon emissions by 1,438.82 tCO_2 e. Converting heating/cooling systems from multi-split and split air conditioners to ground-source heat pumps could reduce emissions by approximately 17,165.84 tCO_2 e.

(3) To reduce lifecycle carbon emissions in hotel buildings, we propose the following decarbonization strat-

egies: extending building design service life, prioritizing exterior walls with low heat transfer coefficients, adopting low-carbon energy-efficient elevators, selecting HVAC systems with higher COP (Coefficient of Performance) for heating and EER (Energy Efficiency Ratio) for cooling under full load, and implementing location-specific solutions.

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